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Panel: Business process management education in academia: Its status, its challenges and its future

Mark O. Lewis
Bentley University, mlewis@bentley.edu

B Sankaranarayanan

A. Rai

RFID-ENABLED PROCESS CAPABILITIES AND ITS IMPACTS ON HEALTHCARE PROCESS PERFORMANCE: A MULTI-LEVEL ANALYSIS

Abstract

In recent years, hospitals have begun to invest in RFID systems to control costs, reduce errors, and improve quality of care. Despite the obvious benefits of RFID in healthcare settings, potential obstacles to effective deployment also exist. The purpose of this study is to systematically understand how hospitals can apply RFID to transform work practices and address cost, safety, and quality of care issues, most notably in inventory management. We leverage an interdisciplinary framework to explore adoption and use of RFID at multiple levels of analysis and adopt a multi-method approach to explore the research questions guiding this study. Our study is expected to contribute to a growing body of research related to the adoption and use of IT in healthcare settings and the enabling role of IT for innovating work practices and improving process performance.

Keywords: RFID, Healthcare IS, Multi-level Analysis, IT-enabled Process Capabilities, IT Adoption

1 INTRODUCTION

The adoption and use of innovative technological solutions for solving business problems have been arguably slow within the healthcare industry (Herzlinger, 2006). However, in recent years, burdened with rising healthcare costs and increased competition, hospitals have begun to invest in advanced IT systems such as RFID-based systems to control costs, reduce errors, and improve quality of care (Datamonitor Report, 2008). In fact, as referenced in Lee and Shin (2007), the global market for RFID systems and tags in hospital settings is expected to increase from $90 million in 2006 to $2.1 billion by 2016 (Harrop and Das, 2006). Nevertheless, despite the obvious benefits of deploying RFID technology, there are some apparent downsides, too. High costs, difficulty integrating with legacy systems and interoperability with life saving medical equipment, incompatible communication standards across major entities in a healthcare network, and entrenched work practices are all potential obstacles to effective adoption and use of RFID in healthcare settings (Smith, 2005).

The focus of this research project, therefore, is to systematically understand how to apply RFID as a transformative technology to address cost, safety, and quality problems in this ever important industry. To narrow our scope, this research focuses on the use of RFID within a bounded set of activities and work processes in the healthcare industry. Namely, we focus on inventory management processes that support the delivery of two types of healthcare services. These services differ on key dimensions related to the variety and value of products used during procedures, the range of procedures performed within the service areas, and the urgency with which services are often performed. We draw from prior research to deepen our understanding of how IT can be leveraged to improve inventory management and purchasing processes (Cohen and Lee, 1998) as well as a broader array of supply chain activities (Rai et al., 2006, Scott and Westbrook, 1991). Although the findings from prior research are relevant and useful, the healthcare context presents some unique challenges for adopting and using IT to improve work practices and the delivery of key services.

First, products and equipment used in medical procedures can be extremely expensive; a basic stent used in a cardiac catheterization can easily exceed three thousand dollars. Second, doctors face high uncertainty in terms of the types and amount of product they will need, due to the diversity in patient characteristics (one size does not fit all when it comes to a stint) and fluctuating volumes. Third, the urgency of medical procedures—where the difference between life and death can be at stake—means that inventory checked out from the holding bins may not be accounted for properly, which makes inventory tracking difficult. Fourth, most hospitals utilize a consignment process for managing inventory, wherein vendors maintain a minimum level of inventory, and hospitals only pay for over-and-above the minimum inventory level. While this lowers the risk for hospitals, it creates issues related to product expiration and tracking due to lack of accountability of the representatives. These contextual characteristics that are specific to healthcare settings lead to our first research question:

1) How do contextual characteristics of healthcare services impact the adoption and use of RFID technologies for inventory management?

In addition to understanding the contextual characteristics that impact RFID adoption and use, it is also important to develop a more sophisticated understanding of the mechanisms through which RFID generates value in specific healthcare settings. Though past studies have moved from a firm-level to a process-level focus for understanding how IT impacts performance (Rai et al., 2006), both types of studies typically remain at a singular unit of analysis. Recent IS research argues that studies adopting a singular unit of analysis have inherent shortcomings, and encourages IS researchers to explore the linkages

between levels of analysis and the processes by which system adoption and use creates value (Burton Jones and Gallivan, 2007). Though the primary focus of this research is on the adoption and use of RFID for improving inventory management processes in healthcare services, we are also interested in the downstream consequences to the work practices that are embedded in the delivery of the specific healthcare services. Thus, inventory management processes fulfill and interface with the delivery of healthcare services, such as the two we have targeted for this study. Therefore, to understand the mechanisms through which RFID generates value (or the obstacles to generating it), it becomes critical to evaluate how the work practices of inventory management change, as well as the corresponding impacts to the work practices of the providers that deliver key healthcare services. Only then can RFID be effectively leveraged and the performance impacts accurately measured. Therefore, the importance of a multi-level analysis in this setting leads to our second research question:

2) How do changes in inventory management work practices (enabled by RFID) correspond to changes in work practices that are embedded in the delivery of key healthcare services?

In the following section, we provide the theoretical background and research model that guide this study, followed by a discussion of the methodology and the plan for completing the project.

2 THEORETICAL BACKGROUND

This article utilizes the IT-enabled process capabilities perspectives (Sambamurthy et al., 2003; Barua et al., 2004; Pavlou et al. 2006, Rai et al., 2006), to study the impact of RFID in healthcare inventory management. According to this perspective, resources refer to the firm's assets such as investments in IT infrastructure, whereas capabilities refer to processes and routines that help a firm to apply and reconfigure resources. The extent to which a firm is able to leverage, reapply and reconfigure its internal resources forms the fundamental basis of its competitive advantage.

Consistent with the IT-enabled process capabilities perspective (Rai et al., 2006), we characterize the investments in RFID technologies as resources, and the corresponding capabilities developed, as RFID-enabled process capabilities. Several technologies have been used for inventory management in the healthcare industry. For instance, bar code technologies combined with inventory management systems have been used in several cases for handling inventory (HealthCareIT News, 2004). However, the characteristics of an RFID-based system (discussed in RFID-enabled process capabilities section) provide unique opportunities for a firm to develop important process capabilities that were previously unavailable to the focal firm (Curtin et al., 2007; Dutta et al., 2007). To develop our arguments further, we draw from extant research on healthcare and supply chain management literature, to build our research model.

3 RESEARCH MODEL

The research model proposed in this article is shown in figure 1. The model postulates that healthcare process performance consists of three dimensions namely economic, structural and clinical performance. Healthcare characteristics, which include inventory uncertainty, patient safety and consignment characteristics are postulated to have a direct impact on healthcare process performance. By eliminating several inventory bottlenecks, RFID-enabled process capabilities are postulated to moderate the relationship between characteristics of healthcare service and process performance. Each of the constructs in figure 1 are described below.

3.1 Healthcare Process Performance

Healthcare process performance refers to the performance benefits realized by the focal hospital for inventory management. It refers to the overall value derived by the focal hospital through its implementation of inventory management strategies and is defined as consisting of three dimensions namely economic performance, structural performance and clinical performance (Solovy and Chaiken,

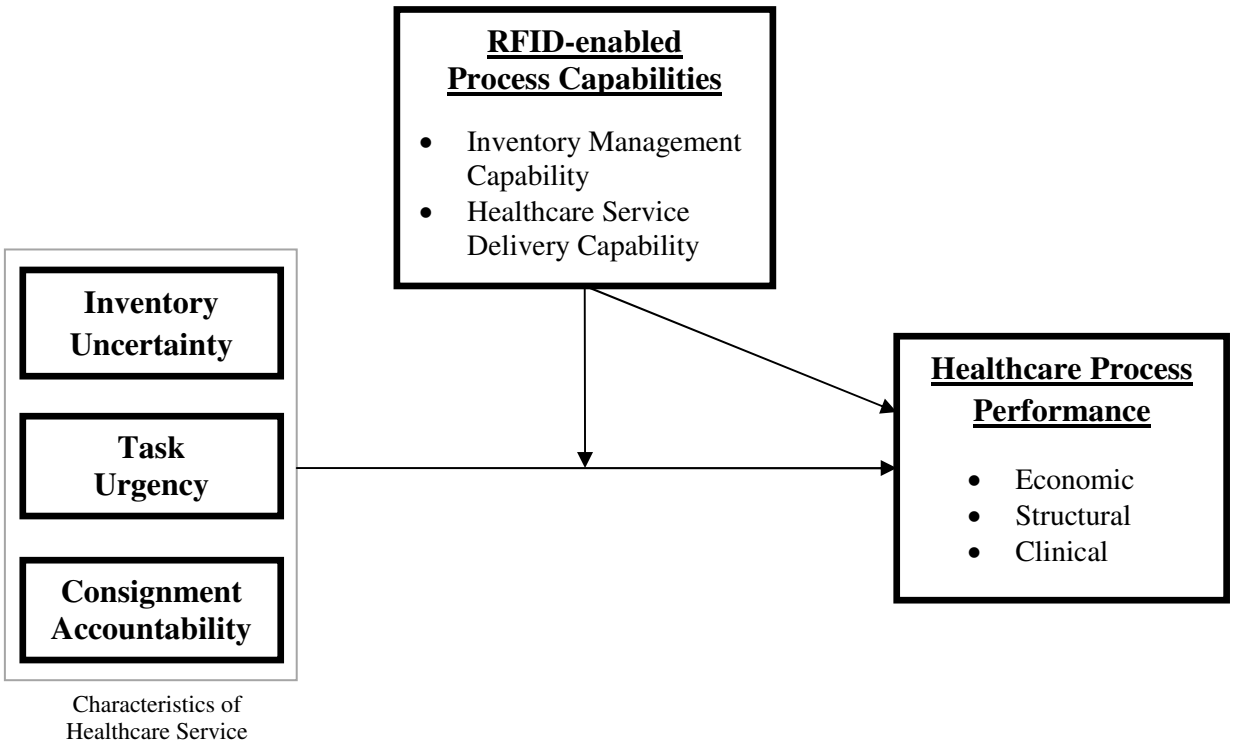

Figure 1. Research Model

2003). These three dimensions refer respectively to the financial, work-related processes, and care-related processes in the healthcare context.

Economic performance refers to the return on investment (ROI) from the implementation of inventory management strategies (Solovy and Chaiken, 2003). IT investments are shown to contribute positively to the production of services (Menon et al., 2000) and to financial performance (Menachami et al., 2006) in the healthcare industry. However, several researchers including Bauer (2004) and Vogel (2003) argue that conventional analysis of ROI, as increase in revenues, has led to a misconception among healthcare practitioners that IT investments in healthcare does not yield positive ROI. They argue instead that in healthcare setting ROI should be computed as *reduction in costs*, and should be based on future cost of health personnel.

Structural performance refers to the process improvements in the functioning of various activities, through the implementation of the inventory management strategies (Solovy and Chaiken, 2003). It includes improvements such as workflow efficiencies in inventory management process, streamlining of inventory management activities, and reduction in processing time, enhanced inventory turns, less inventory shrinkage, increased visibility and provision of secure information.

Clinical performance refers to the process improvements in the various patient-care processes, through the implementation of the inventory management strategies (Solovy and Chaiken, 2003). It includes

improvements in processes such as reductions in inventory errors associated with a patient, reductions in inventory use due to mistakes, and streamlining of inventory ordering for patients.

These performance dimensions refer to the multi-level impacts in healthcare. While economic and structural performance refer to the inventory process performance (therefore at the process-level),

clinical performance relates more to the delivery of care, which we consider to be the higher-order impacts. Therefore, to understand the mechanisms through which RFID generates value (or the obstacles to generating it), it becomes critical to evaluate how the work practices of inventory management change, as well as the corresponding impacts to the work practices of the providers that deliver key healthcare services within this context.

3.2 Characteristics of Healthcare Service

Healthcare context presents some unique challenges for realizing inventory management performance benefits. These contextual considerations are documented under the umbrella term healthcare characteristics. We refer specifically to three healthcare characteristics that have an impact on inventory management practices, and subsequently to healthcare process performance, namely: Inventory uncertainty, Task urgency and Consignment accountability.

3.2.1 Inventory Uncertainty

Hospitals typically manage their inventory in a centralized repository, and is transferred to individual departments based on the patient needs and the procedure performed (Duclos, 1993). Most often, doctors have specific preferences for the type of inventory (such as stents, catheters) to be used in a procedure, than being dictated by hospitals or vendor consultants, and is argued to be a "big source of the inefficiency in healthcare" (McCarthy, 2006, p. 291). Also, predicting the exact product to be used in a procedure is difficult. This uncertainty in inventory requirements means that the number of inventory picked from the central location to the procedure room is usually over-and-above the required set of inventory. Inventory wastage in hospitals happens because such additional inventory is not replaced, accidentally misplaced, or is trashed. Such inventory wastage could contribute to lowering of economic performance in inventory management.

3.2.2 Task Urgency

Task urgency refers to the stress related to the task and the corresponding time pressure faced by the doctors, nurses and hospital staff while performing a particular procedure. Prior research on the work conditions in hospitals, has shown that work-related stress experienced by hospital staff and nurses are consistently high (Caplan, 1994; Stordeur et al., 2001). The stress level in operating rooms and catheter labs are even more pronounced, given the nature of the task performed, such as surgical and emergency procedures. As doctors and nurses face task urgency, the focus is more on the procedure performed, rather than on the handling or management of inventory used in the procedure. This implies that inventory tracking takes lower precedence compared to other important tasks, and could lead to decreased economic performance because of inventory wastage. In other cases, wrong inventory might be chosen in a hurry by the hospital staff and nurses. As the possibility of medical errors due to incorrect inventory exists (McNutt et al., 1997), task urgency could also lead to a decrease in clinical and structural performance.

3.2.3 Consignment Accountability

Consignment system refers to the practice by which vendors own the inventory, until such time it is actually used by the hospital (Ballard, 1991). This practice is a variant of the vendor managed inventory

(VMI) system (Williams, 2000), wherein the vendor assumes inventory risks while stocking, and takes responsibility for replenishing it, and the hospitals pay only after the inventory is used.

Although hospitals stand to benefit from such a system due to decreased inventory risks and costs, consignment system also has important limitations. First, in the consignment system, inventory check is performed by vendor consultants on a scheduled basis (batch activity), instead of on-demand basis (transaction-based) (DiGiacomo, 1991). For hospitals that see fluctuations in demand in inventory (such as accidents increase in certain times of the year), having scheduled inventory replenishment by the vendor could be problematic, due to inventory unavailability. Second, inventory tracking is typically done manually by a vendor consultant. This could lead to errors in inventory tracking, and can subsequently lead to ordering of unnecessary inventory. Both these aspects affect economic performance, as inventory costs increase due to potential last minute ordering of inventory. Clinical performance is affected because inventory expiry could cause problems in providing effective patient care. In addition, due to additional labor involved in constant inventory tracking, structural performance could also be affected.

3.3 RFID-Enabled Process Capabilities

Despite the commonly held belief that digital capabilities are fundamental to an organizations survival and growth, scholars still struggle to specify the underlying mechanisms that link IT investments to improved performance in organizational settings (Bharadwaj 2000). Recent work in this area continues to call on researchers to investigate the causal pathways that connect IT investment and firm performance (Rai et al., 2006; Sambamurthy et al., 2003, Ho et al., 2002). For instance, one area of particular interest in IS research today is the role and potential impact of IT in healthcare organizations (Kohli and Grover, 2008; Fichman et al., 2008).

As noted, the healthcare industry provides a unique context for organizational scholars. For instance, the management and distribution of hospital inventory is often discussed under the broad heading of inventory management (Nicholson et al., 2003). Inventory management is an often researched topic among operations research scholars (Scott and Westbrook, 1991; Turner, 1993) who focus largely on functional problems (Rai et al., 2006). However, inventory management takes on a new light in hospital settings, as one distinct feature relates to the use of periodic review par levels (also termed order-up-to level) for managing inventory (Nicholson et al., 2003). It is not the use of periodic review or par levels that creates the distinction in hospital settings. Rather, these par levels are seldom based on actual usage patterns, and instead reflect the desires of doctors and nurses which are often based on subjective criteria (Prashant, 1991).

In contrast to their storied past, hospitals and other healthcare establishments are expected to increase their investments in advanced technologies—such as RFID— to improve operational efficiencies in areas such as inventory management, and to enhance patient care (Datamonitor Report, 2008). However, to generate value from these IT investments, scholars increasingly argue that organizations must leverage the functionalities of these digital resources to create higher order capabilities, such as innovating business processes, shaping new strategy, and extending the enterprise network (Sambamurthy et al., 2003). This logic extends from the resource-based view of the firm (Barney, 1991), and suggests that digital assets alone are not sufficient for increasing firm performance (Powell and Dent-Micallef, 1997; Zara and Covin, 1993).

RFID enabled process capabilities can improve inventory management in specialty hospital settings by reducing par levels through increased product use visibility. Specialty hospital settings relate to practice areas where high risk procedures are conducted and high value (greater than $2000) products are likely used. By using RFID in these settings, the collection of information across activities— those that are coordinated within a specialty process (such as a cardiac catheterization or interventional radiology

procedure)—is automated. As a result of the limited human intervention necessary for information collection, materials managers can get a near real time digital representation of material flow within practice areas. This newfound visibility can also be combined with and enable new work practices to develop higher order capabilities for improving cost management, enhancing patient safety, and enabling regulatory compliance in hospital settings.

4 RESEARCH METHOD

We will use a multi-case study method to explore the possible impact of RFID technologies on inventory management practices in healthcare settings, as well as the potential corresponding changes to work practices that are embedded in two distinct service areas: Cardiac Catheterization (CCL) and Interventional Radiology (IR). The case study approach was chosen because it affords the best opportunity to dive deep into the contextual conditions (Yin, 1994) that impact process performance in hospital settings, as well as to explore how RFID is used to improve work practices at diverse contexts. To determine case sites, we are guided by principles of theoretical replication, which lead us to choose sites where the phenomenon under investigation can be explored in its natural setting (Yin, 1989), and so we can test our assumptions that predict divergent results but for predictable reasons (Yin, 2003). Guided by this philosophy, we will conduct a retrospective analysis of four service delivery sites that exist in separate hospitals (two CCL labs and two IR labs). This approach allows us to ensure variance along important contextual characteristics that are assumed to impact process performance over time.

In addition to cross case comparison, we have also identified key roles within each study to explore the impact of RFID technologies at multiple levels of analysis. In doing so, we will interview individuals that have adopted and are now responsible for using RFID to improve inventory management within the healthcare settings (supply coordinators, purchasing managers, and inventory clerks). Additionally, we will interview individuals that participate in the work practices that are directly responsible for the delivery of services rendered in the CCL and IR labs in major US hospitals (doctors, nurses, lab attendants). Miles and Huberman (1994) refer to this as within case sampling, which is an additional way to develop rich insight from case study research (Chu and Robey, 2008). By conducting a multi-level analysis, our interest will not only be on the change that occurs within practice areas, but on the causal linkages that connect changes in inventory management practices with changes in the primary work practices, those that are directly related to the delivery of key healthcare services.

4.1 Data collection

This multi-case study will use three data collection techniques to explore the phenomenon and ensure adequate validity of research findings (Yin, 2003; Miles and Huberman 1994). The primary source of data for this study will be a series of semi-structured interviews. Interviews were first conducted from the perspective of a vendor of RFID solutions in the healthcare industry, and included discussions with C-Level employees such as the Chief Executive Officer, the Vice President of Hospital Services for CCL labs, and the Director of Hospital Services for IR labs. Upon completion of these early exploratory interviews with the vendor, we conducted our initial interviews with members of the first site identified, a CCL lab from a large hospital in the Northeastern part of the United States.

The interview protocol is semi-structured and consists of questions that are both targeted and open-ended to encourage normal conversation related to the peculiarities of the healthcare context and the impact of RFID on work practices and process performance. More specifically, questions ask respondents to assess aspects of the healthcare context that most influence their work, how their perceptions and work practices change at early and late stages of RFID adoption and use, how they use the RFID technology to alter their work practices, and how the overall performance of the unit has changed (in terms of employee

satisfaction, patient safety, and inventory carrying costs) as a result of the RFID technology. Table 1 provides an overview of the questions from the interview protocol and their relation to major constructs in this study. Except for early interviews focused on discovery and gaining access to case sites, interviews will last between forty-five minutes to one hour long and will all be recorded and transcribed.

The second source of data will be direct observation, which reflects a data collection method where the researcher acts as a passive observer (Yin 2003). Observational evidence is particularly valuable when acting as a supplement to other data collection strategies (Mason, 2002). Mason (2002) states that the term 'observation' "usually refer to methods of generating data which entail the researcher immersing himself in a research 'setting' so that they can experience and observe at first hand a range of dimensions in and of that setting" (pg. 84). We leverage this method to observe firsthand the activities that occur in CCL and IR labs, how RFID technology is used to alter inventory management work practices that support these service areas, the procedural linkages that connect inventory management practices with the work practices that enable service delivery, and the contextual characteristics that shape behavior in these work domains.

The third source of data will be archival, which is an important source of data for this study as it provides a means to triangulate findings that emerge from semi-structured interviews and direct observations. In addition to power point slides, meeting notes, and white papers generated from both the vendor and hospital perspectives, we will leverage data generated from use of the RFID system. This data reflects usage patterns and changes to inventory levels of tracked products over time.

Dimensions	Working definitions and key interview questions
Healthcare Context	We focus on how actors view the unique aspects of the work domain and how they related to characteristics of the healthcare context. Such aspects relate to time pressure, issues with consignment, process importance (life and death scenario), and process complexity. *Examples questions:* What is unique about the healthcare context that impacts adoption and use of RFID technology? Please describe the contextual situation surrounding hospital X when they purchased the RFID solution. Are there unique aspects of the following (CCL, IR, OR, etc.) hospital units that affect adoption and implementation in different ways?
RFID-Enabled Process Capabilities	We focus on how individuals perceive that the RFID system has enabled changes in inventory management and healthcare service delivery in specific healthcare settings. *Example questions:* How has the use of RFID afforded you the opportunity to alter your work practices? How does increased visibility impact decision making related to inventory par levels and acquisition of new and existing assets? How do innovations in inventory management work practices impact patient care?

Process Performance	We focus on how participants view the impact of RFID technology on key performance outcomes within their work domain related to economic, structural, and clinical outcomes. *Example questions:* How has RFID technology and the subsequent changes in work practices impacted inventory par levels of key products in your work domain? How has RFID technology and the subsequent changes in work practices impacted patient safety in your work domain?

Table 1. Protocol for data collection

4.2 Data analysis

We leverage a hybrid analytical technique to analyze the qualitative data, incorporating both inductive and deductive coding and thematic development procedures to generate rich insight (Fereday and Cochrane, 2006; Chiasson et al., 2008). The hybrid approach is particularly useful in novel settings where extant work is limited; it allows us to begin the analytical process by working from the data and move from specific cases to more general conclusions (Schwandt, 2001). Moreover, by alternating inductive and deductive analysis, we are able to leverage the IT –enabled organizational capabilities framework to interpret emerging themes, which will result in richer and more robust findings.

Two of the authors are conducting the interviews for this investigation. After each interview, both authors meet repeatedly in recap sessions to converse on major themes that emerge from the interviews. The third author is then presented with the generated themes and offers critique of the early analysis by reference to prior theory. Additionally, a third party is transcribing all interview files. During the early phases of analysis, the research team will thoroughly listen to, read, code, and discuss the data in an iterative fashion (Eisenhardt, 1989). Themes generated through analysis of individual interviews will be identified by tagging text segments with codes using computer assisted qualitative analysis tools. Saliency as an explanatory factor, rather than its frequency, represents our standard for what constitutes a theme (Glaser & Straus, 1967; Blatt et al, 2006).

4.3 Expected Contributions

The findings from this research study have important potential implications for researchers and practitioners alike. From a research standpoint, the domain of healthcare IT is an emerging field requiring more theoretical and empirical research contributions. Our study attempts to make an important contribution in the healthcare IT context, by examining the contextual factors and impacts of RFID-enabled capabilities on healthcare process performance. Future research can build on our research model by seeking to understand the different dimensions of RFID capabilities in different healthcare scenarios such as patient-tracking, and investigating patterns of use of RFID in different healthcare contexts, and their corresponding impacts on adoption. Practitioners can stand to benefit from this research study, by gaining a better understanding of the various internal factors that inhibit their healthcare process performance. By understanding the impacts of RFID-enabled capabilities, practitioners can effectively utilize these capabilities, for improving their information visibility, tracking, and validity, thereby increasing their healthcare performance.

4.4 Project Status

Our research is being conducted in two phases. The first phase focuses on qualitative interviews from individuals within the vendor firm and four hospitals in the United States. Currently, we have conducted interviews with respondents from the vendor firm and one major hospital. Our next steps will be to complete the interviews with representatives from the other three hospitals. Upon completion of this phase, we will move into the quantitative longitudinal analysis of archival data that are currently being collected by the RFID system within each hospital setting. Through this analysis we will triangulate findings generated from the first phase of our study, as well as search for new insights that may emerge from our longitudinal analysis.

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